Electromyography

Uses and Limitations

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• **A normal muscle at rest emits no detectable electric current, but in action, in diseases of the muscle and in denervation it emits electric impulses characteristic of these states. The impulses can be amplified and studied through the sonic and oscilloscopic patterns they create. These patterns are sufficiently different so that simple atrophy of disuse can be distinguished from the denervation that may be associated with it. Since denervation can be localized to individual muscles and thence to the nerves controlling them, electromyography serves much the same function as myelography, with comparable accuracy and with greater safety and simplicity. It aids in the diagnosis of several muscular diseases of children and adults.**

Because electromyographic changes due to injury do not appear until 18 to 21 days later, a study made soon after injury can either disclose or rule out preexisting lesions. Then a later study indicating denervation is objective evidence that any disability is due to the injury in question.

THE ELECTROMYOGRAPH is an electronic device that amplifies and converts the minute voltages picked up by a needle electrode inserted into a muscle, expressing these currents by loudspeaker or visually by a cathode-ray oscilloscope. By this means the electric potentials of normal, diseased or denervated muscle can be studied. Normal muscle has two significant electromyographic characteristics: It emits no detectable impulses at rest, and on insertion of the needle electrode the electrical activity caused by the mechanical stimulation of insertion is quickly dissipated.

Muscles whose nerve supply is injured or diseased have typical changes in electromyographic response, reflecting hyperirritability. Abnormalities are most likely to appear on insertion of the needle—sharp wave activity and fibrillation. The mechanically induced reaction may wane in a few seconds and activity may cease, or spontaneous fibrillation may continue. Polyphasic motor units may appear on contraction; but they are clinically important only when associated with sharp waves or fibrillation. In the early days of electromyography, undue importance was attached to polyphasic motor units in the anterior compartment of the leg, until it was learned that many normal persons give this response because of habitual pressure on the peroneal nerve due to crossing the legs or to lying in bed for long periods.

Myopathic conditions also give rise to characteristic findings,[2,4,5] classified electromyographically as dystrophic or myotonic. Dystrophic impulses are characteristically of low amplitude but rapid sequence and are under voluntary control. The myotonic states are distinguished by an intense high-frequency discharge on needle insertion, persisting for many seconds. The discharges may also be elicited by percussion on the muscle in the region of the needle, or by voluntary contraction of the muscle, but they cannot be voluntarily stopped. The auditory signal from this high-frequency discharge is best described by the term, "dive-bomber effect."

Artifacts that may interfere with electromyographic observation are numerous and the changes they cause may closely simulate those of recognized abnormalities. Although the experienced myographer learns to recognize many of these accidents, he also insists on clear-cut and reproducible findings which are manifestly clear of such accidents. Common causes of misleading findings are improper grounding of the patient and the machine; cardiac impulses and tremor discharges; disturbances caused by diathermy machines, radio waves or interference with house-current, loose contacts in the electromyographic circuit and defective insulation of the needle electrode.[3] The most misleading factor, and the most difficult to eliminate, is incomplete relaxation of the muscle being examined. Some patients have great difficulty in relaxing the muscles of the posterior neck and the back.

The electromyographer must not restrict his examination to a certain area merely because the referral mentions no other; he must be ready to investigate as far as his examination leads him. For this he must be able to place the electrode precisely, knowing exactly in which muscle belly he is inserting it, and he must further know the root supply of the muscle and its peripheral nerve if he is to localize lesions as precisely as electromyography permits. For this and other reasons, when the physician

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delegates electromyography to technicians or other less qualified persons he immeasurably reduces the validity of the examination.

Besides the polyphasic motor units previously described, so-called "fasciculation voltages" may occur in many disease states and occasionally in normal muscles. Similarly, myotonic impulses are not limited to the myotonic states; they have been observed in peripheral nerve injury, dermatomyositis, polymyositis, Marie-Charcot-Toothe disease, progressive spinal muscular atrophy and arthrogryposis.[2,3] Dystrophic motor units, too, have been reported in other conditions than muscular dystrophy —scleroderma, acrosclerosis and lupus erythematosus. These irregularities should be reported, therefore, as impulses or motor units of a myotonic or dystrophic type, with no attempt to draw a diagnostic inference, unless the pattern predominates in the electromyographic tracing. Conversely, the referring physician must not place too much importance on the finding of occasional patterns of the myotonic or dystrophic type.

An apparent error in localization occasionally occurs. The electromyographic findings may indicate clear-cut involvement of the first sacral nerve root but myelography show a defect at the fourth lumbar interspace. The reason of course is that a medially and inferiorly herniated nucleus pulposus at the fourth lumbar interspace may compress the first sacral nerve root intradurally rather than the fifth lumbar root which exist laterally at this level. Therefore, both the electromyographer and the neurosurgeon must keep in mind that electromyographic evidence of involvement of the first sacral root may be due to either a medially located lesion at the fourth lumbar interspace or a laterally located lesion at the lumbosacral interspace.[7]

In two reported series the accuracy in localization and detection of root compressions by herniated nucleus pulposus and tumor was not significantly different. In Bonner and Schmidt's series of 30 patients there was 80 per cent exact localization by electromyography as proven by subsequent operation.[1] In 24 of 30 patients, disease in the disc was found at the exact level detected by the electromyograph. In four of the remaining six cases, the report was not completely accurate although it was of definite clinical value; in two cases the lesion was not localized by this means.

In Shea, Woods and Werden's series of 75 cases there was 90.7 per cent accuracy of electromyographic diagnosis as confirmed by operation.[7] Myelography was done in 68 of these cases with accuracy of 85.3 per cent. Clinical experience has shown that when myelography and electromyography are both used in the same case the accuracy in establishing the existence of a root lesion and localizing it exactly is much better than when either method is used alone, since findings are seldom negative from both when root involvement exists.

The conclusions of Marinacci after evaluation of 157 cases of laminectomy, all studied by electromyogram and all but ten by myelogram, were as follows: "The electromyograph is of great value where the myelographic findings are normal or indefinite, especially so in the lumbosacral lesions. The myelogram is of a more localizing value than the electromyogram in L-3 lesions." In his experience when definite root compression existed the electromyogram was 80 to 90 per cent accurate in determining exact localization.[4]

USES AND ADVANTAGES

The uses and advantages of electromyography are many. In the first place it supplies objective findings which are not obtainable by any other means. There is direct observation of impulse from the muscle fiber itself without intermediary procedures which could add error. The test is extremely sensitive and is actually a microphysiologic examination of a minute area of muscle and its nerve supply. It is entirely objective. The patient cannot change, influence or alter the findings. There are no after-effects or complications. The cost is reasonable. The test may be performed in the office.

Electromyography is not designed to take the place of a neurological examination or roentgen or other laboratory procedures. The findings have no more nor less significance than other diagnostic data, although in certain circumstances this method affords valuable information which is otherwise not obtainable. In peripheral nerve injuries the ability to localize the lesion, to determine extent of involvement and to follow the progress of reinnervation is outstanding.

Electromyography is of great diagnostic value in differentiating atrophy due to disuse, denervation or primary muscular disease. In atrophy of disuse the electromyographic response is characteristically normal, but the disuse may be associated with nerve damage, and the two elements are difficult to separate clinically. The area atrophied by disuse may be proximal, adjacent or distal to the area of denervation,[6] but it does not respond to electromyography with the sharp wave activity and fibrillation characteristic of denervated muscle. The same difference in response may help to distinguish between atrophy due to denervation and that due to disuse as a result of malingering or hysteria. On the other hand, if a patient with a conversion reaction also has organic denervation, electromyographic study may clearly delineate the extent of each. Muscular diseases, too, can be distinguished in cases where disability may

be erroneously attributed to injury or occupation.

True muscular atrophy such as in amyotrophic lateral sclerosis and progressive spinal muscular atrophy is characterized by denervation activity in the pleurisegmental pattern. Infectious neuronitis (Guillain-Barré syndrome) typically involves most severely the muscles supplied by the longest axons; hence the distal muscles are most strongly affected. Atrophy of muscle as a result of myopathy is a problem occasionally seen in adults but is more common in children. There is dystrophic activity in muscular dystrophy and myotonic activity in the myotonias. The clinical problem of differentiating between poliomyelitis and muscular dystrophy is resolved by the finding of either a dystrophic pattern or the pleurisegmental lower motor neuron abnormalities of poliomyelitis.

An important feature of traumatic electromyographic changes is that they do not appear until 18 to 21 days after injury. Therefore a study made immediately after injury cannot indicate the extent of injury; and if denervation is disclosed at that time, it must be due to a preexisting lesion. Conversely, if denervation is not detected immediately after injury but appears after 21 days, it is evidently due to the recent injury and not to a previous one—a distinction of great practical importance in questions of workmen's compensation and other liability for injury.

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